QUIKPAS: A MICROCOMPUTER BASED
PASSIVE SOLAR ANALYTICAL DESIGN TOOL

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Abstract

Social and economic pressures are causing architectural designers to resume their responsibility to consider the effects that design decisions will have on the thermal performance of buildings. Recent studies have shown that conservation techniques and passive solar design are the two most cost effective strategies for reducing the energy costs of buildings. Although much research has been done in energy conserving techniques, many designers have been unable to implement these strategies because they do not have a means of evaluating the thermal performance of a building during the design process. Several analytical tools have been developed but they are usually complex computer programs that many designers find too cumbersome, time consuming, and expensive to use in the design process.

The use of analytical methods as design tools is discussed, stressing that designers should use them more as educational tools to gain a clear understanding of the principles involved so that thermal aspects of buildings will intuitively be included in their thinking during the design process.

QUIKPAS is a microcomputer program that accurately models the thermal performance of buildings, asking for information and giving results in a manner that is condusive to the internalization process which will allow a designer to integrate the thermal aspects of buildings into his or her designs. A comprehensive discussion of the features of QUIKPAS is given.

Thesis Supervisor: Harvey J. Bryan
Title: Assistant Professor of Building Technology

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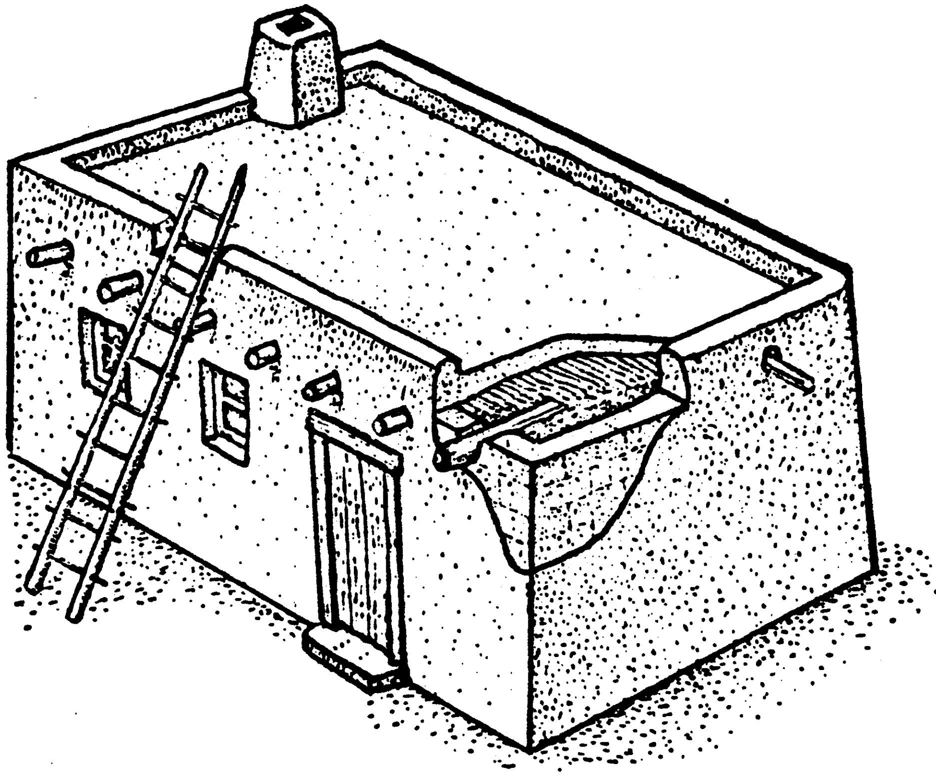
INTRODUCTION

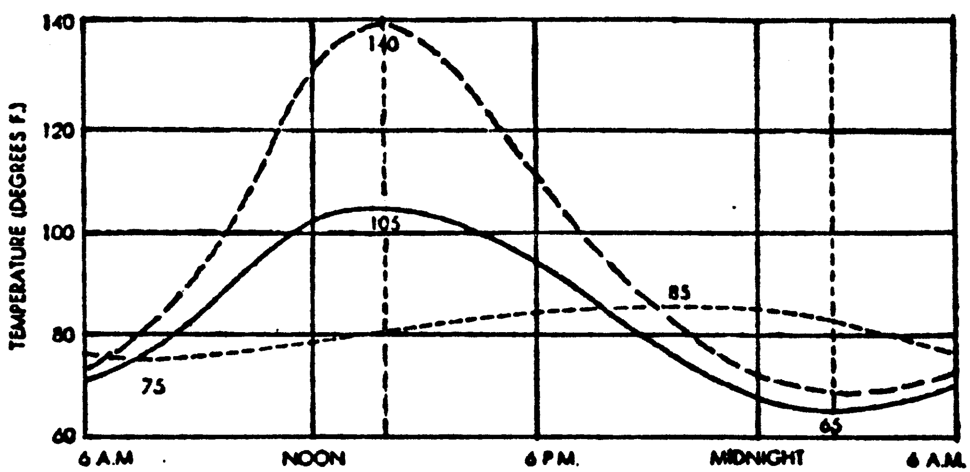
Until about the beginning of the Twentieth Century, the thermal performance of a building was a factor that architects had to consider as a part of the design process. The heating, ventilating, and air conditioning (HVAC) systems that are used today to maintain comfort in buildings (and, in some cases, are necessary to make a building inhabitable) simply did not exist a hundred years ago. Heating "systems" consisted mainly of fireplaces and stoves and used wood and coal as fuels. These "systems" were inefficient and incapable of providing the large amounts of heating energy that is often required today to keep room temperature at a comfortable level on a cold day. Mechanically driven fans were not used effectively until the late 1880's (1) and air conditioning was not invented until 1906 (2), so the only methods of keeping a building cool were natural ventilation and prevention of overheating by building design.

This period of time is what Ed Mazria refers to as the "pre-industrial" age of architecture. He divides architectural history into three time periods based on the energy usage characteristics of buildings: pre-industrial, industrial, and post-industrial. (3) Buildings during the pre-industrial age were designed to respond thermally to their climates. Residential buildings in different climates provide good examples of this architectural response to climate.

In New England, where winters are quite cold and windy, houses were built tightly around a central chimney which provided heat. The northern elevation had few windows and the roof line was constructed in a manner which allowed the prevailing winds to flow over the building and not into it. Houses in the hot, humid, southern regions of the United States were characterized by large open verandas which provided a buffer zone between the outdoors and inner spaces. High ceilngs were used to allow hot air to rise and keep the lower part of the room cool. In the desert climate of the Southwestern United States, where the temperatures are very hot during the day and very cold during the night, adobe was commonly used as a construction material.(4) The thermal properties of adobe allow the inside temperature to remain at a fairly constant, comfortable, temperature despite large diurnal temperature swings (see fig. 1.1).

The industrial age of architecture began in 1928 with the first mechanical air conditioning system used in the Milan Building designed by George Willis, architect, and M.L. Diver, engineer.(5) Because of the development of more and more sophisticated mechanical systems to condition the air and the availability of cheap fuel to power them, architects did not have to concern themselves with the thermal aspects of building design. They could design a building in virtually any form in any climate and allow a mechanical engineer to design a system that would maintain comfort in the building. During this period, buildings





ROOF SURFACE
OUTSIDE TEMPERATURE
INSIDE TEMPERATURE

Fig. 1.1 Adobe Construction Keeps Indoor Temperature Stable Despite High Diurnal Temperature Swings.

From Fitch and Branch, "Primitive Architecture and Climate", Scientific American, Vol. 203, No. 6, Dec. 1960, pp.133-144.

of the same type began to have the same basic appearance no matter what climate they were in. The same building could just as easily be found in the cold Northeastern United States as in the hot Southwest. Only the HVAC systems had to be different to maintain comfort in different climates and the design of these systems was delegated to the engineers. All the architect had to do was leave a space between the real ceiling and a false ceiling to accomodate the duct work and other equipment used in the HVAC system.

We are now in the beginning of the post-industrial age of architecture. The energy needed to power the HVAC systems used to condition spaces is no longer cheap and the fuels used are no longer plentiful. Two recent examples have dramatically illustrated this point: the oil crises of 1973-74 and 1978-79, and the natural gas shortage of 1980-81 that affected the Northeastern United States. The people who have to pay the bills to operate the HVAC systems have become painfully aware of the fact that energy costs have risen during the last decade substantially faster than inflation.

The "energy crises" is not over. The nuclear technology that once promised to be able to replace conventional fuels with electrical power that would be "too cheap to meter" has proven to be much more expensive than was predicted, both in economic and in social costs. The economic cost has become so high that United States utilities have not ordered a new nuclear power plant since 1979 and have cancelled many previous orders. This is quite understandable when one realizes that almost all of the recently completed reactors have cost over ten times the original price, have taken from twelve to fourteen years to complete, and the utilities have discovered that the demand for electricity is not as great as projected. All of these factors create a time span on the order of forty years for capital investment.

The social costs are harder to measure, but problems of using both conventional fuels and nuclear power are many and varied. Fossil fuels (such as oil, gas, and coal) are non-renewable and will, therefore, ultimately not be available. Their use also causes great environmental disorders such as pollution, acid rain, oil spills, and possibly nonreversible changes to land caused by strip mining. Nuclear power creates radioactive waste materials which will remain dangerous for over six hundred years (some of it perhaps over ten thousand years). This waste must be disposed of in a manner that can ensure that it will not leak into the environment, an event that can be triggered by erosion, leeching, earthquakes or other natural disasters, or tampering. Any solution to this problem presupposes that the disposal site must be in an area that will be geologically and politically stable for a minimum of six hundred years. By contrast, the United States has only been in existence a little over two hundred years. No solution has been devised for the safe handling and storage of nuclear waste material and there is much speculation that no solution is possible.

A viable alternative to conventional and nuclear power is what Amory Lovins refers to as the "soft" path of technology. He projects that we could eventually meet all of our energy requirements by using renewable energy sources such as solar, wind, and hydroelectric power.(6) The key to making the "soft"path work is conservation of energy. A study done at the Harvard Business School reports that "conservation may well be the cheapest, safest, most productive energy alternative readily available in large amounts." (7) The study also states that the two most cost effective strategies for reducing building operating costs are 1) conservation, and 2) use of passive solar energy.(8)

Passive solar and, less obviously, conservation techniques are basically building design problems. The basic design of a building is the single most important factor affecting the amount of energy necessary to condition the interior. The American Institute of Architects has concluded that savings of up to sixty percent can be accomplished during the initial design process. (9) Thus, in the post-industrial age of architecture, as in the pre-industrial age, the thermal aspects of a building are architectural design considerations.

The problems concerning the thermal performance of buildings have changed because building technology, materials, and usage are quite different from a hundred years ago. Commercial buildings are generally much larger and they generate measureably more heat than pre-industrial age buildings. These factors greatly affect the cooling requirements of buildings. But although the questions concerning energy uses are harder to answer, more is known about thermal performance and several tools have been created to help designers understand how building design parameters affect the thermal performance of buildings.

A BRIEF OVERVIEW OF THERMAL PERFORMANCE PREDICTION METHODS

The first method that was devised to deal with the thermal aspects of buildings was one developed during the 1930's by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) to determine the sizing of heating,ventilating, and air-conditioning systems.(1) It was a fairly simplified procedure that looked at the static heat flow in and out of a building during peak conditions. The purpose of the method was to ensure that the HVAC system installed in a building would always be able to provide comfortable conditions (i.e., maintain air temperature and relative humidity). This was accomplished by installing an HVAC system that could meet the peak load conditions (i.e., the hottest and the coldest times of the year). Although the procedure cannot be classified as a design tool by today's standards, it is discussed here in order to help gain a historical perspective of the progress that has been made in developing tools to predict the thermal performance of buildings. One must remember that this method was developed before the age of computers, when it was not possible to make the myriad calculations necessary to accurately predict the thermal response of a building to its climate.

The method was based on the simple equation of static heat flow:

$$Q = U\ A\ dT$$

where Q is heat flow rate, U is the heat conductance of a material, A is the area of the material, and dT is the difference in temperature between the two sides of the material. The method assumes that to maintain a given condition during the winter the heating plant will have to deliver heat energy into the building at the same rate that heat flows out of the building. Similarly, to maintain comfortable air conditions in the summer, the cooling plant will have to remove heat at the same rate that heat is introduced into the building.

The equation, $Q = U\ A\ dT$, can only be used directly to determine static conductive heat flow through materials. This static, or "steady state", approach is an inadequate representation of reality since both weather patterns and thermal responses of buildings are dynamic in nature. The ASHRAE procedure uses several methods to incorporate other types of heat flow (convection, radiation, and mass transfer) into the equation. Allowances are made for infiltration (mass transfer) and a crude procedure was devised to account for the fact that, during the summer, the outside temperature of sunlit walls and roofs is effectively much higher than the ambient temperature (an effect known as the "Sol-Air" temperature) and the effects of this "Sol-Air" tmeperature is transmitted into the building at varying rates depending on wall and roof construction. (2) The ASHRAE method is to use a Cooling Load Temperature Difference (CLTD) to account for this phenomenon. These procedures all suffer from the limitations of a static approach to a dynamic problem.

The purpose of the ASHRAE procedure was to ensure that the HVAC plant was large enough to maintain comfort in all conditions; it became common practice to estimate the size of the system by following this procedure and then add an arbitrary "safety factor" of twenty-five to fifty percent. More modern methods have now shown that this practice often resulted in equipment that was twice as large as actually needed, leading to unnecessarily high first costs and low operating efficiencies.

During the 1970's, detailed computer simulations were utilized to establish empirical formulas that correlate steady state design parameters with local monthly average weather conditions to determine the potential contribution of solar energy to meet heating requirements of residential buildings. The Solar Load Ratio (SLR) method is an example of this technique. The results and limitations of this approach can be seen by studying figure 2.1. The spread of data points shown in the figure and the curve derived from these points indicate the potential for error in the application of this method.

These methods are, however, generally easy to learn and use, cheap (requiring no more equipment than a handheld calculator), and give

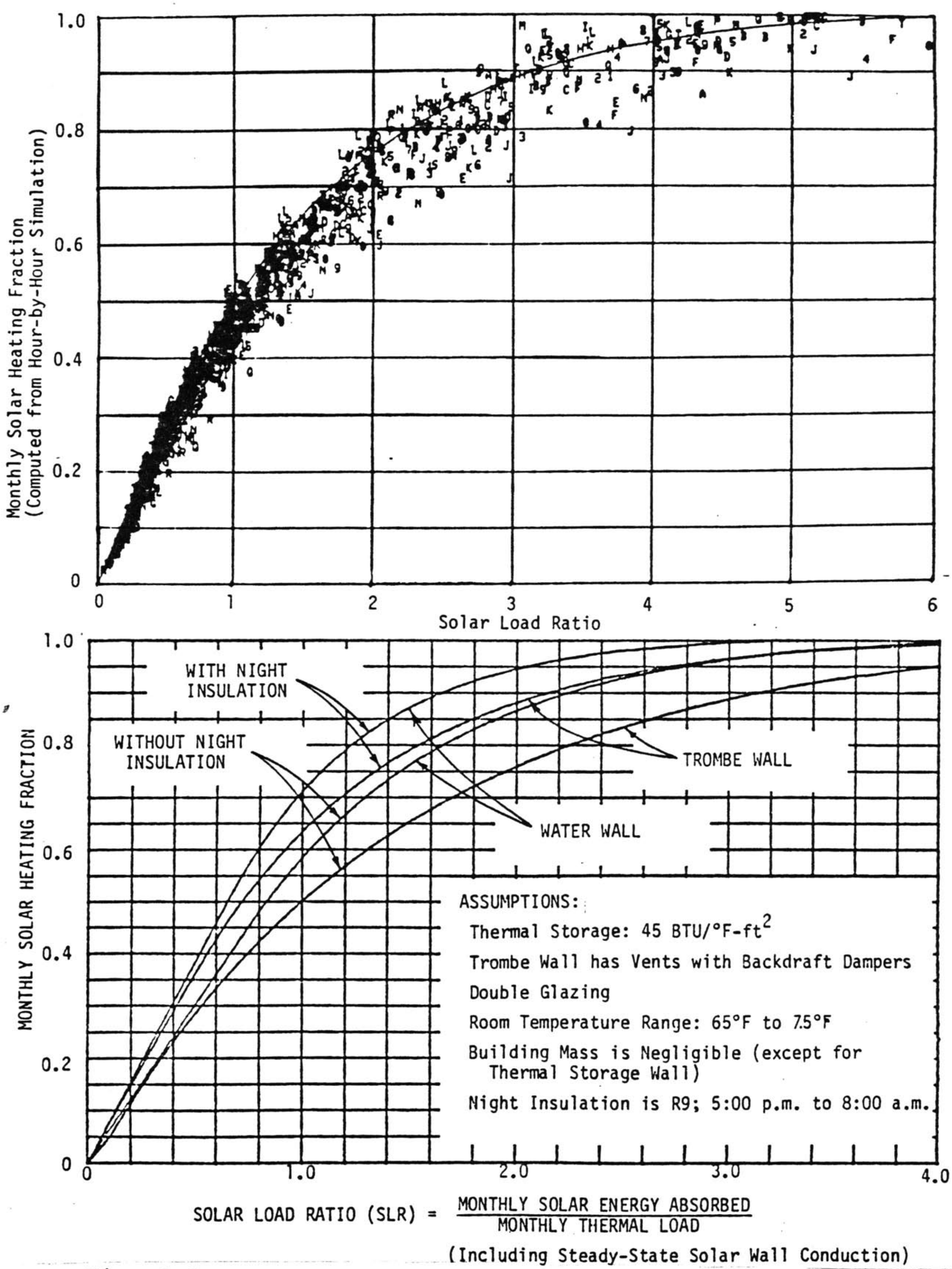


Fig. 2.1 Establishing Correlation Factors Between Solar Load Ratio and Monthly Solar Heating Fraction.

relatively quick results (typically fifteen to thirty minutes). The main disadvantage of this approach is its lack of flexibility. If the building under consideration has design parameters that differ significantly from the original correlation assumptions (the "base-case" building), then the results obtained will not be accurate. As a consequence, correlation methods cannot be used for studying widely varying types of construction. In addition, these methods tend to predict only the heating energy requirments of a building and neglect other important design information such as cooling requirements, peak load conditions, and temperature profiles.(3)

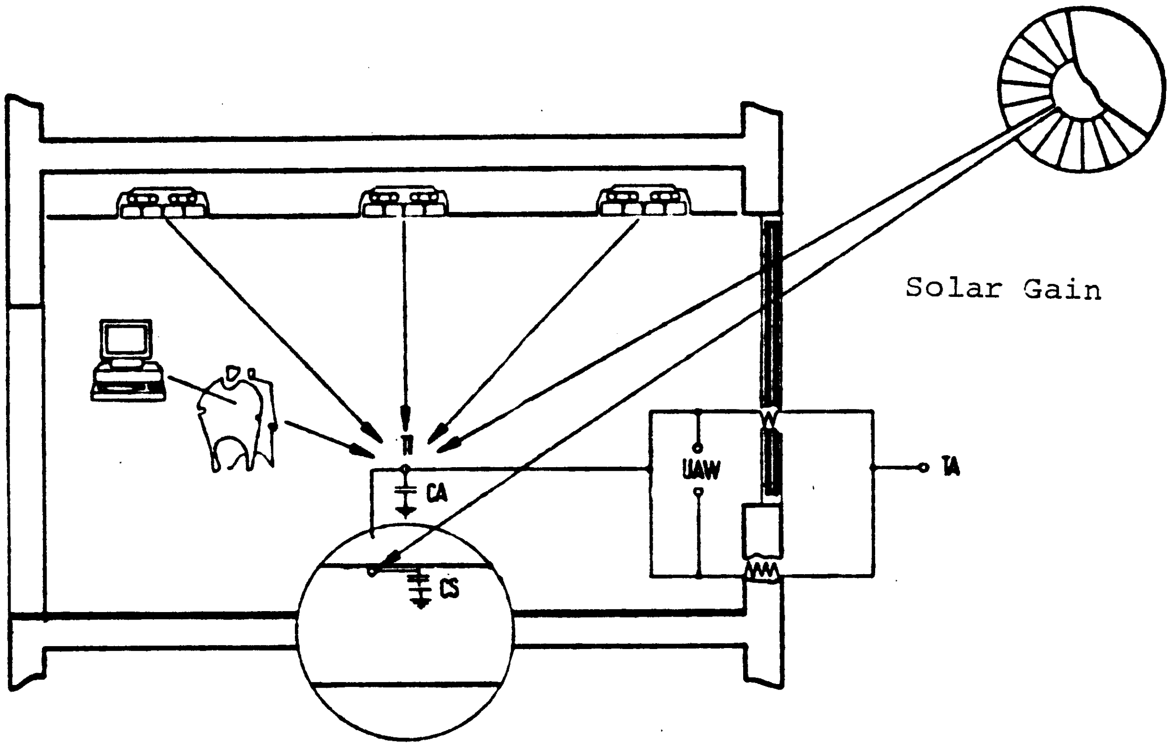
Simulation methods based on the dynamic heat flow in and out of building envelopes were also developed during this time period. Two basic approaches were used: those using a transfer function (such as DOE-2) and those using a thermal network type of equation (such as CALPAS or BLAST).

The transfer function method first calculates various response factors of building components to determine the transient flow of heat through the exterior components of a building (e.g., walls, roof, and floor). These factors are calculated as a function of the materials used in the construction of these components (e.g., concrete block or stud walls, insulation, etc.). These functions are used to compensate for the fact that heat flow through walls and solar gain through windows does not reach the interior air instantaneously but rather is absorbed first by some opaque material (viewed as thermal mass, usually the interior walls, ceiling, or floor slab) which subsequently transfers the heat into the interior air space and eventually is seen as a load on the HVAC system. (4)

Thermal network equation methods are based on the fact that heat flow can be viewed as being analogous to electricity flow; temperature differences (or other driving forces) are analogous to voltage differences, structural materials and insulation (flow retardants) are analogous to resistors, and thermal masses (storage) are analogous to capacitors. A building can be represented mathematically exactly as though it were an electrical circuit (see fig. 2.2) and the heat flows can be determined by predicting what electrical currents would flow through various parts of thecircuit depending on various voltage changes (which represent climatic changes).

In both transfer function and thermal network simulations, once the equations which represent the building have been determined, these equations can be manipulated by using weather data which is usually interpreted as a set of irregular time-dependent functions that can be represented on a small (one day - 24 hours) or large (one year - 8760 hours) time scale.

The simulation approach overcomes many of the limitations of static heat flow methods such as the ASHRAE method or the newer correlation methods.



 - Heat of Lights

 - Heat of Equipment

 - Heat of Occupants

TA - Outdoor Temperature

TI - Indoor Temperature

UAW - Resistance of Walls and Windows

CA - Zone Heat Capacitance

CS - Slab Heat Capacitance

Fig. 2.2 Thermal Network Analog of Heat Flow

Simulation methods are flexible enough to allow a designer to specify almost any type of construction and also give results concerning many aspects of the thermal performance of the building being studied (heating, cooling, and ventilation requirements, peak load conditions, etc.). However, these methods (especially the larger, annual hourly simulation ones such as DOE-2 or CALPAS) require the use of large computers, which are often cumbersome and expensive to use. Many design firms cannot afford to purchase the equipment required to run simulation programs so they must rent computer time from time-sharing facilities. This almost always leads to a batch type of input which can be very intimidating and confusing to many designers. Another problem that occurs with time-sharing methods is that the output is generally delayed (sometimes as much as a day). As a result, simulation methods have tended to be used mainly as analytical tools in that they are used only to test the final building design and are not used as an aid during the design process.

Because of the limitations of the correlation approach and the high costs of the simulation approach another method was developed that falls somewhere between the two. This method is known as the bin or, temperature frequency, method. "Both heating and cooling loads can be estimated using this method. It involves making instantaneous energy calculations at several different outdoor temperatures and weighting each result by the number of hours of temperature occurrence within each bin. The bins are usually five degrees in size and are often collected in three daily eight hour shifts. Mean coincident wet-bulb temperature data, for each dry-bulb bin, are used to calculate latent cooling loads for infiltration and ventilation. The bin method considers both occupied and unoccupied building conditions and gives credit for internal heat gains. For example, a calculation would be performed for forty-two degrees (representing all occurrences of 39.5 - 44.5 degrees) and with building operation during the midnight to 8 A.M. shift. Since there are twenty-three bins between -10 and 105 degrees and three shifts, sixty-nine separate operating points would be calculated." (5) The final load is determined by summing up the sixty-nine separate results. This method is complicated to use and is somewhat inaccurate as it is still based on steady-state approximations of heat flow.

Perhaps the main reason that so many methods have failed to become truely useful as design tools is their tendency to be "opaque" to the designer; that is, they do not impart to the designer a clear understanding of how building design affects thermal performance. As stated above, simulation methods are often very cumbersome and so detailed that the designer does not obtain a feel for the relationships between input (design parameters) and output (thermal performance).

The same problem occurs with correlation methods because they often ask for input that is a synopsis of design parameters, not the parameters themselves. An example of this is the Solar Savings Fraction - SSF - method developed at Los Alamos Scientific Labarotories to analyse passive solar buildings. (6) The method requires a designer to calculate the "Collector Load Ratio" (CLR) of a building which is defined as the "Building Load Coefficient" (BLC) divided by the solar collector area (AC). The BLC is the heat loss coefficient of the building envelope exclusive of the heat loss of the collector area. The results produced by the method are presented as a monthly and annual Solar Savings Fraction, which is defined as the fraction of heating energy required by a non-solar "base-case" house which can be saved by using passive solar heating techniques. No other aspects of thermal performance are addressed. Thus, the actual thermal performance of the house under consideration is arrived at only indirectly by comparing it to a non-existent building. Since the specifications of the house being studied are lumped together into only two variables, it is difficult for a designer to see what effects, if any, that various changes in his or her design will have on the thermal performance of the building (e.g., what happens if the roof R-value is changed?).

The advent of the microcomputer presents the opportunity to combine the best qualities of these methods: the accuracy and flexibility of simulation and the speed and economy of correlation methods. In addition, the microcomputer can be easier and quicker to use than any of the previously available methods because of its tremendous capacity to be "user-friendly". This feature is a direct result of the ability of the microcomputer to be programmed using an interactive approach. Large computers have been prevented from using such features because of the high cost of the computer and connect time necessary for an interactive approach program. Unlike large main-frame computers or time-sharing facilities, microcomputers are completely self-contained (often no larger than a typewriter), highly accesible, and relatively simple to operate. Their low cost (typically less than $5000) makes them very affordable to design firms which are traditionally small in size. They have become commonplace in the home, school, and office, where they are performing functions like word processing and accounting. (7)

The first public domain microcomputer program to use the simulation approach was MICROPAS (8), a program funded by the California Office of Appropriate Technology. It is based on the annual hourly simulation program CALPAS1, a thermal network type of program designed to model passive solar buildings. CALPAS1 and its subsequent versions (most notably CALPAS3) are generally well respected for their ability to accurately predict the thermal response of buildings to their climates and have been used extensively in the passive solar research and design communities.

MICROPAS was designed to run efficiently on a microcomputer by utilizing statistically compressed hourly weather data to represent annual weather patterns. These weather data are produced by a program developed by the National Bureau of Standards called SELECT (9) which reduces fifty-two weeks of weather data to six weeks of representational data (used to predict overall thermal performance) and two weeks of peak weather data (used to predict peak conditon performance). The MICROPAS program produces results which are comparable to those of CALPAS and it has been certified for use under the 1982 California Residential Building Standard (see fig. 2.3). However, for reasons that will be discussed in the following chapters, the author feels that MICROPAS does not utilize the full potential of the microcomputer for interactive communication with a user. It does, however, form a solid foundation from which a useful design tool can be produced.

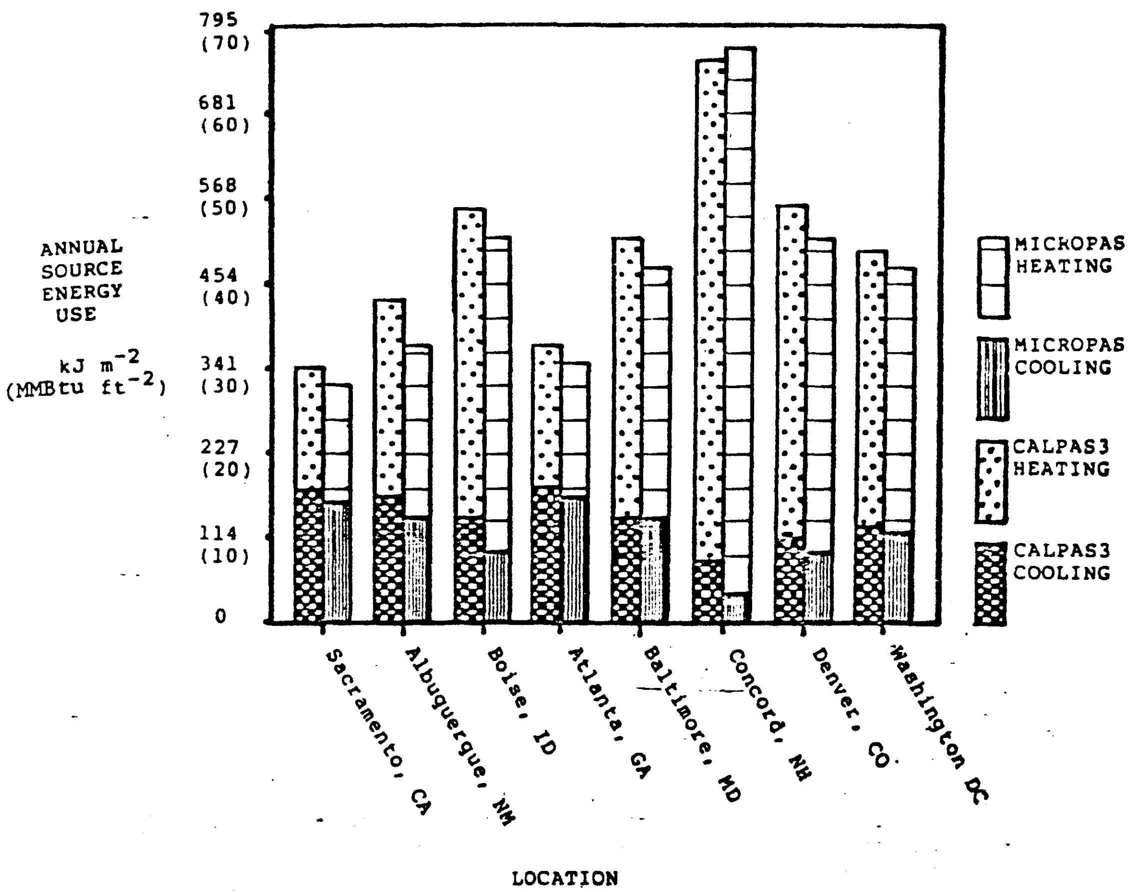


Fig. 2.3 Comparison of MICROPAS and CALPAS3 Predictions

From Nittler and Novotny, "MICROPAS, An Annual Hourly Heating and Cooling Building Simulation for Microcomputers", Proceedings of the Eighth National Passive Solar Conference, Sante Fe, New Mexico, September, 1983.

THE ROLE OF ANALYTICAL MODELS IN THE DESIGN PROCESS

The questions that are raised concerning how buildings respond thermally to their environment are quite complex, requiring an approach that can take into account the numerous design factors that affect the building (such as orientation of the building, insulation values of the walls and roof, size and type of glazing, etc.) and that can illustrate the equally numerous responses that a building can have to these factors (heat flow in and out of the building envelope, temperature swings, humidity levels, etc.). As noted in the preceding chapter, the simulation techniques that utilize the computational power of computers are capable of answering these questions but are generally so unwieldy that they are not very useful in the design process, whereas correlation techniques, while simple to use, do not provide enough information necessary to make critical design decisions. The microcomputer has the capability to offer the computational power of a computer to a designer in a manner that can be readily used. The question is, how best can this new tool be incorporated into the design process?

Since the computational power of a computer can only be accessed through the use of a computer program, any design tool that uses this capability must take the form of a computer program. Such a program will need to have the qualities of any good design tool:

- it should be easy to use, even by people with no special knowledge (of computers)
- it should be understandable, asking for information and giving results in terms familiar to a designer
- it should be capable of being used during various aspects of the design process, producing results at many different levels
- it should be educational in nature, allowing a designer to clearly understand the principles involved in solving the problem at hand. (1)

Because computers are binary logic machines responding only to "yes or no" type questions, computer programs generally take the form of linear algorythms, proceeding in a strict, step-by-step, sequence from the beginning of the program to the end. This type of "structured" programming is necessary to solve the complicated, iterative algorythms that programs are designed around and it allows programmers to detect flaws which inevitably occurin the logic of their programs. However, this style of programming also leads to the rigid batch type of input (and output) that many non-computer oriented people find difficult to use.

For example, CALPAS3 (2), a commercially available simulation program based on the original CALPAS1, uses a batch input to illicit information from a designer that requires him or her to enter data into the computer in a rigorous, step-by-step, procedure. Every component of the building must be described in the proper order (e.g., roof, then walls, then thermal mass, then glazing, etc.) or the program will reject the data. For instance, if the designer should happen to describe the various glass used in the building before he or she describes the walls, the program will respond with the somewhat cryptic message "INPUT...LINE xxx...COMMAND OUT OF ORDER OR *END MISSING." Furthermore, error messages do not appear until after the designer has entered the entire building description, causing him or her to search through all the input to understand why the program will not run. This approach often leads to a designer being more concerned with how the information is entered rather than with the building design itself.

In addition, the designer must specify any output reports to be generated other than a standard annual report before the simulation run is made. If, upon reviewing the standard report, the designer has questions regarding other aspects of the thermal performance of the building, he or she must run another simulation using the same building description, but adding to the input data his or her request for additional information.

The interactive approach to programming is somewhat different. It is still "structured" in that the program runs in a sequential sequence after all of the necessary information has been entered, but the input and output sections of the program are written in a manner that allows the user to decide the order in which he or she wants to enter information and to decide how much output and the order in which the results will be displayed. In a sense, this can become an "open-ended" program in that the user, not the program, can decide when and how to halt program execution. This more closely resembles the design process, which is very definitely non-linear in nature but is more of a cyclic routine in which a designer moves back and forth from problem formulation to solution (to formulation to solution, etc.) until he or she reaches an acceptable ending point.

One example of the interactive approach to programming as applied to predicting thermal performance of buildings is the Computerized Instrumented Residential Analysis or CIRA (3). Although the algorythms used are fairly crude and the program was intended to be used as an audit tool rather than as a design tool, CIRA demonstrates many of the characteristics that a good design program should have; most notably it provides very flexible input and output options to its user. A designer can enter the characterics of a building in any order desired, describing, in familiar terms, only those components that are relevant to a problem at any one particular time. Once an analysis has been made, the user can then select any one of several reports as needed and can even create new reports of his or her own choosing. This style of programming is much more condusive to the design process, allowing a designer to work relatively quickly between problem formulations and problem answers.

But how a designer perceives and uses any design tool is even more important than the structure of the tool itself. Harvey Bryan writes:

> No matter how elegant or refined these [design] procedures may or may not be...the ultimate test has been their validity to the design process. (4)

When a designer uses an analytical method as a design tool he or she should be aware that the structure of the procedure is often biased towards certain types of designs. This is true of any design tool but is especially true of analytical tools which calculate "exact" answers based on the parameters given them and on the assumptions that the methods make. It behooves the designer to find out what these assumptions are if he or she is to find these tools to be truely useful.

The designer must not lose sight of the fact that the design process is really a synthesis of many factors viewed as a whole. It is impractical to use several methods to obtain the "best" solution for various aspects of a design and expect to be able to combine all of these answers into one overall solution. Methods that analyse only one aspect of a design often produce "optimum" results that are definitively incompatable with "optimum" results of methods which analyse other aspects of the design. Such a fragmented approach to design would be similar to attempting to design a building by designing all of the rooms seperately as "perfect" rooms and then putting them together to form a "perfect" building. (5)

A better use of these tools is to use them more as learning tools and to "internalize" the principles involved rather than attempting to obtain an "optimum" design solution for each aspect of the design. Bryan calls internalization:

> ...closely akin to what many designers might call intuition. In its simplest form internalization is a learning process that allows a designer to learn about the problem under consideration in such a manner that the problem solution becomes second nature to the designer - like learning to ride a bicycle. (6)

From this standpoint, the educational aspect of a design tool is its most important quality and a designer will find that he or she will obtain the most value from such a tool by using it to facilitate the internization process.

The educational process does not stop when a designer leaves school; his or her knowledge of the design process will continually expand as experience is gained in the design field. However, a designer cannot be content with merely perfecting familiar techniques but must also pursue information about new design techniques and materials used in the building industry. This applies to conservation techniques and solar architecture just as much as it does to learning about the latest steel or glazing material available. The old adage of, "the more you have the more you can make" is just as true with education as it is with money and could be rephrased as, "the more you know the more you can learn."

In every aspect of design, a designer starts by mastering a few basic principles that form a foundation on which he or she can build further knowledge. A good design tool, then, can best help a designer learn new skills by initially illustrating some basic principles and by encouraging a more indepth exploration of a problem as time and interest permit. The designer should be able to use the tool with very little time needed to learn how to use it and without being confronted with too many unfamiliar terms and/or technical details. Then, having become more proficient in the use of the tool, he or she should be able to study a problem in greater detail until eventually, having internalized the information, the designer will no longer need to rely on the tool.

Of course, if new design problems arise, such as a client wanting an entirely new type of building or a building being located in a completely different climate, the designer can always return to the tool to explore these new aspects, much as a person can return to a textbook to brush up on details that he or she may have forgotten or may not have paid attention to in the past because they were not applicable at the time.

Microcomputers using interactive programs have these capabilities. A well designed interactive program allows the user to carry on a dialogue between him orherself and the machine, with the user communicating with the computer by typing on a keyboard, manipulating a "joystick" or "mouse", or even, in the near future, by voice-activated signals. The computer responds with written words, symbols, graphs, or sounds. (7) The more instantaneous the feedback from the program, the easier it will be to use and the less frustrated the user will be in his or her efforts to understand how to use it.

Ease of use is a very important quality that a computer based design tool should have. Even the most sophisticated program that has the ability to allow a designer to specify literally thousands of variables should be written in a manner that requires the designer to enter only a few variables (certainly less than twenty) and still get meaningful results. This can be accomplished by assigning "default" values to most of the variables that the program will respond to. Default values are values that the program will assign to specific variables unless otherwise specified by the user. They should be visible so that the user is aware of them but should require no action by the user to specify them. This feature allows a designer to quickly learn how to use the program and also provides him or her with the opportunity to explore new aspects of the problem whenever the designer has the time or the inclination to do so.

The designer still has the responsibilty to understand that even the best design tools are limited. The answers that are produced can only be as accurate as the information entered into the program. Computer people refer to this phenomenon as "GIGO" for "Garbage In, Garbage Out." This is not limited to the data entered by the designer, but also is a function of the weather data used by the program. This data is generally representative of the weather that occurs at the closest airport to the building being analalysed so it cannot be totally accurate because the micro-climate conditions at the building site cannot be taken into account. The best way to utilize these programs is to make parametric comparisons, changing one variable of the design at a time and seeing what the relative responses are to these changes. A design tool should be designed to facilitate this type of use, encouraging the user to play "what if?" games and giving rapid feedback to the various questions being asked.

THE QUIKPAS PROGRAM

The preceding chapters have discussed the qualities that a computer program should have if it is to be useful as a design and/or educational tool (the author views these terms as being synonymous since good design tools are educational tools). Keeping these qualities in mind, the author wanted to develop a program that could be used as a tool by all members of the design community (architects, engineers, students, etc.) during various stages of the design process to analyse the thermal performance of various types of residential and commercial buildings.

The first consideration given to the program was that it had to able to accurately model all of the relevant thermal aspects of buildings (design parameters and climatic weather patterns). Particular attention had to be given to cooling loads because the internal heat generated in commercial buildings, coupled with their low volume to skin ratios, results in buildings that are generally cooling load dominated.

As stated in Chapter 2, a public domain program called MICROPAS which uses a thermal network hourly simulation approach has been developed. (The public support for MICROPAS was withdrawn in January, 1983, when the Office of Appropriate Technology (OAT) was eliminated. It can, however, still be obtained from the California Energy Commision and is commercially available from ENERCOMP, the company which wrote the program under a grant from OAT.)

The MICROPAS program is capable of meeting the criteria for accuracy and flexibility but does not have all of the qualities necessary to make it a good design tool. The main disadvantage to the program is that is somewhat difficult to use. For example, to create a new building description, the program uses a linear input structure which requires a designer to enter new values or actively accept default values for well over one hundred variables. Since a designer is not necessarily concerned with many of these variables, he or she can develop the habit of rapidly pressing the "Enter" key over and over, trying to get to the variables that are of concern. Unfortunately, the designer can get ahead of the program and may find that he orshe has inadvertently accepted an incorrect default value. The designer must wait until all of the building description has been entered before he or she can correct any such incorrect entries.

When editing an existing building, the designer is confronted with a matrix display such as seen in figure 4.1. If the designer wants to change, for example, the area of the EWALL, he or she first has to enter the "Number of data change" (which is 2), and then must instruct the program to change the value of "ROW 2, COLUMN 2". It is even more difficult to delete a wall from a building description; if the designer reduces the "NUMBER OF OPAQUE SURFACES", the program deletes the last surface listed (in this case SLABEDGE) which is usually not going to be

```
MICROPAS     Date - 10/22/83     User - Anybody     Program - EDIT

MICROPAS DATA CHECK LOOP
------------------------
OPAQUE SURFACES BETWEEN ZONE AND AMBIENT

 0) NO CHANGE
 1) NUMBER OF SURFACES (20 maximum) : .................. 6

 2) ROW OPAQUE  AREA    U-VALUE  AZIMUTH  TILT    ABSORP-  ZONE
        SURFACE (sf)    (Btu/sf) (deg)    (deg)   TIVITY   NAME
                                                  (FRAC.)
    ----- 1 ---- 2 ------- 3 ----- 4 ------ 5 ------ 6 ----- 7 ----
    1  SWALL     300    0.0942   0        90      0.5      HOUSE
    2  EWALL     200    0.0942   -90      90      0.5      HOUSE
    3  NWALL     330    0.0942   180      90      0.5      HOUSE
    4  NWALL     200    0.0942   90       90      0.5      HOUSE
    5  ROOF      1500   0.0353   0        0       0.5      HOUSE
    6  SLABEDGE  150    1.1      0        0       0        HOUSE


Number of data change or 'A' for all ?
```

Fig. 4.1 Typical MICROPAS Description Screen the wall that the designer wanted to delete.

The features of MICROPAS that make it a good base for a design tool are:

- it is accurate
- it is capable of taking into account all of the relevant design and climatic factors that affect the thermal performance of buildings
- it is accessable because it is written in BASIC, a computer language which is supplied with virtually every microcomputer on the market.

Because of these features, the author decided to use the basic core algorythms of MICROPAS and write completely new input and output sections (those parts of a program that interact with the user and can, therefore, determine how easy a program is to use) to produce a program capable of being a good design tool. The input and output sections of this new program, called QUIKPAS, were modeled after those of CIRA and of MICROLITE (1), a program developed at the Massachusetts Institute of Technology for modelling daylighting effects.

QUIKPAS is written to operate on an IBM PC microcomputer; it requires 128 K of RAM memory and two double-sided, double density floppy disk drives (320 K of storage on each disk). This equipment was chosen because it is a fairly popular microcomputer and uses a version of BASIC that is relatively compatiable with other microcomputers (i.e., only a few changes will have to made in the program code to enable the program to run on other machines).

The program is capable of modelling a building with up to three independent thermal zones, with each zone having its own HVAC systems and thermostat controls. Each zone can be described with up to eleven exterior opaque surfaces (ten walls and a roof), thirty-three glazing surfaces (thirty windows and three skylights), and three thermal masses. The walls and windows can be oriented in any direction and tilt, and the windows can be modeled with overhangs, thermal shutters, and/or sunscreens. Windows are described as part of the walls to allow for easy modifications of glass area; the designer simply has to change the area of glass and the area of the wall that the window is in will automatically be changed. (Many programs separate the windows from the walls which forces a designer to change the area of both components in order to change the area of either.) Internal heat gains for each zone can be varied on an hourly basis. In all, there are over two hundred different types of variables that a designer can use to describe a building. The program can actually accept over a thousand variables since several of the types of variables are used many times.

QUIKPAS produces extensive thermal performance predicticon reports. Annual, seasonal, daily, and hourly reports are available, and various reports show such aspects as heating, cooling, and ventilation energies necessary to maintain each zone at the selected thermostat settings, temperature profiles, climatic data, etc.

Because of the large number of input and output variables, it is impossible to display all of them to the user at any one time. To break the variables down into manageable displays, QUIKPAS uses a system of menu driven description screens. Three basic menus exist: main program, building description input, and output. The designer selects a desired program option from the "SELECT PROGRAM OPTION" screen (fig. 4.2). This is done by using the cursor keys to highlight the various options; the user depresses the "Enter" key to select the desired option when it is highlighted. This method is used throughout the program whenever an option is to be selected.

To analyze a particular building, a designer would first select the "CREATE A NEW BUILDING FILE" or "EDIT AN EXISTING BUILDING FILE" option. If the "EDIT" option is selected the program will display the names of all of the building descriptions that currently exist on the data file diskette in use. After a building has been selected the "BUILDING DESCRIPTION OPTION" screen appears (fig. 4.3). The program will go directly to the "BUILDING GENERAL INFORMATION" screen (fig. 4.4) if the designer selects the "CREATE NEW BUILDING" option so that he or she can first assign a name to the new building.

The "BUILDING DESCRIPTION OPTION" screen is divided into three parts: Zone Descriptions, Component Descriptions, and Interzone Descriptions. QUIKPAS initially comes with a library of components (such as different types of glass, overhangs, thermal mass, etc.); however, a designer can

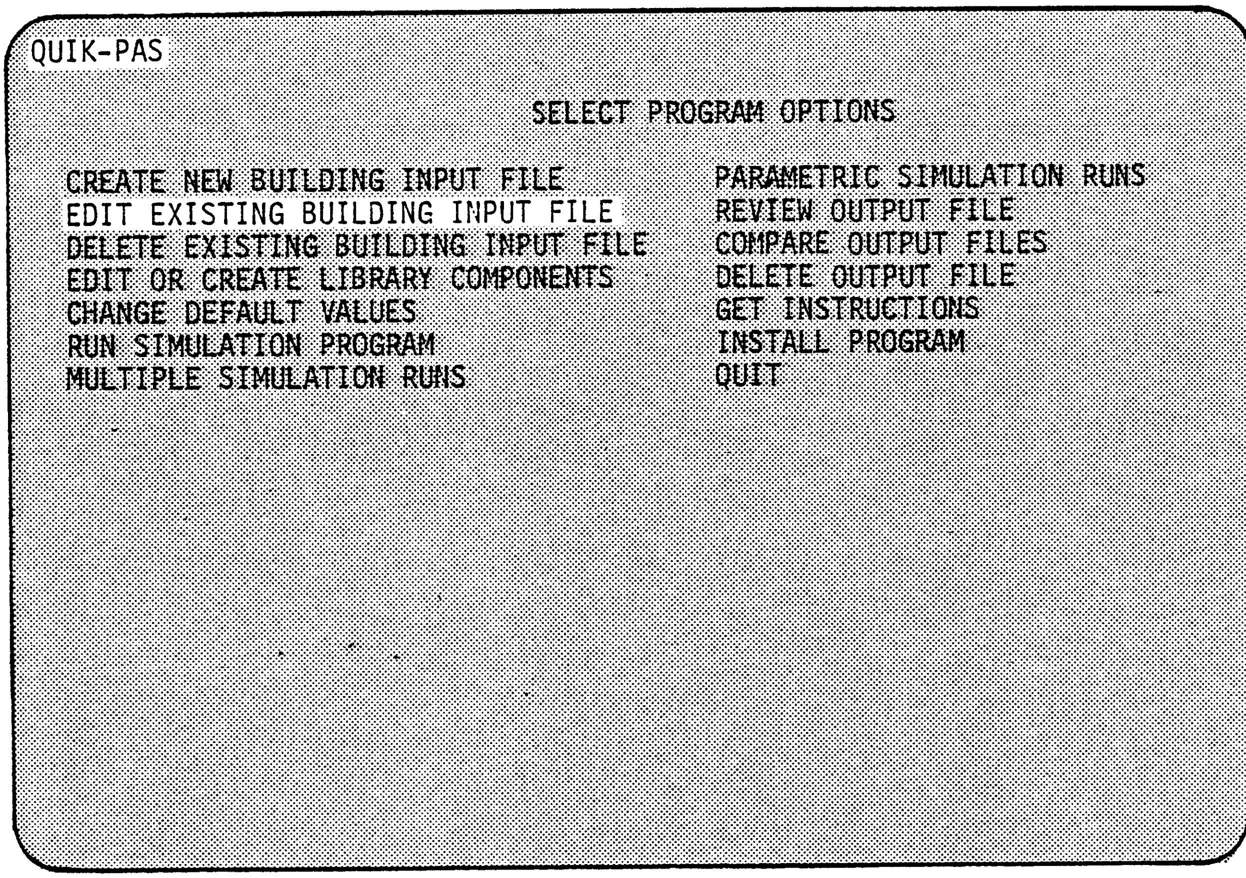


Fig. 4.2 QUIKPAS Main Program Menu

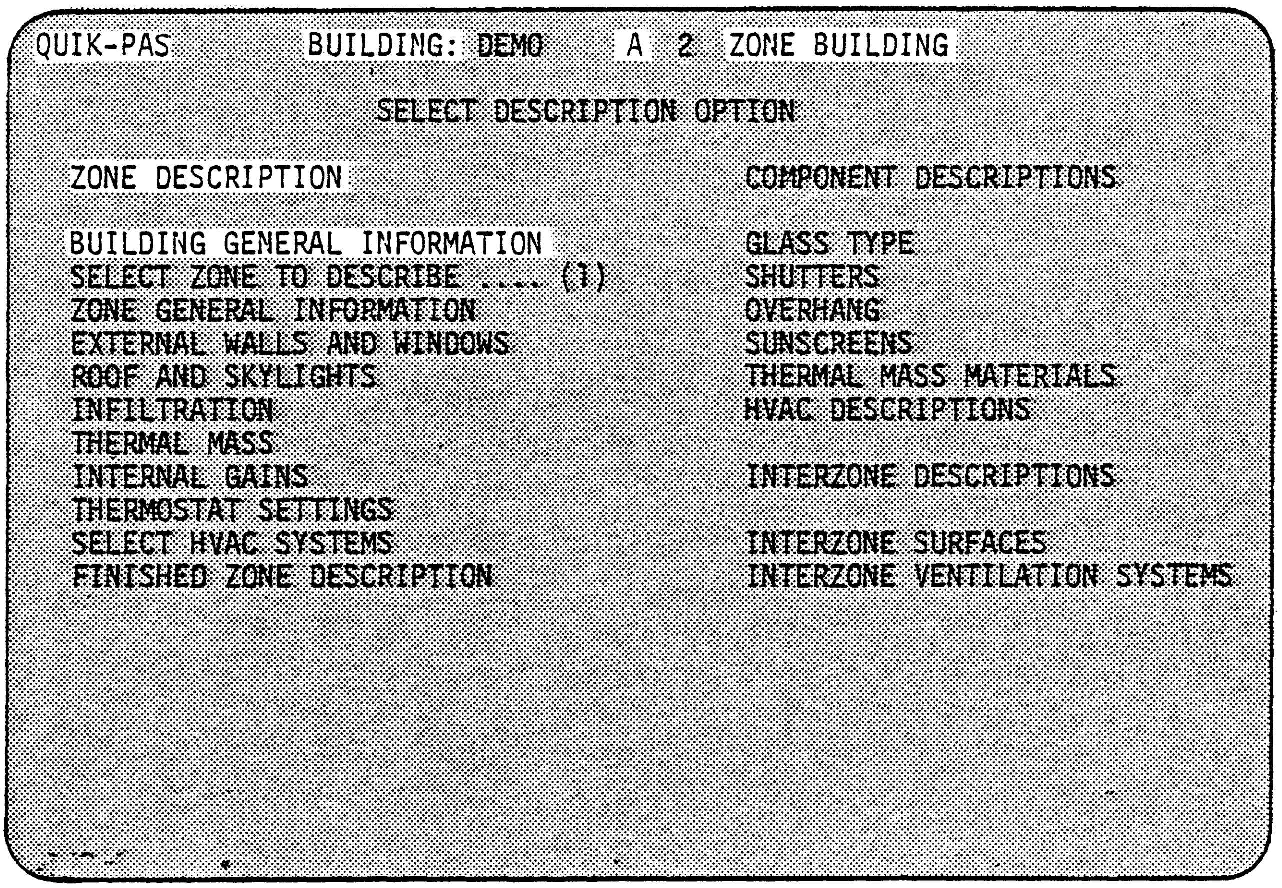


Fig. 4.3 QUIKPAS Building Description Input Menu Screen

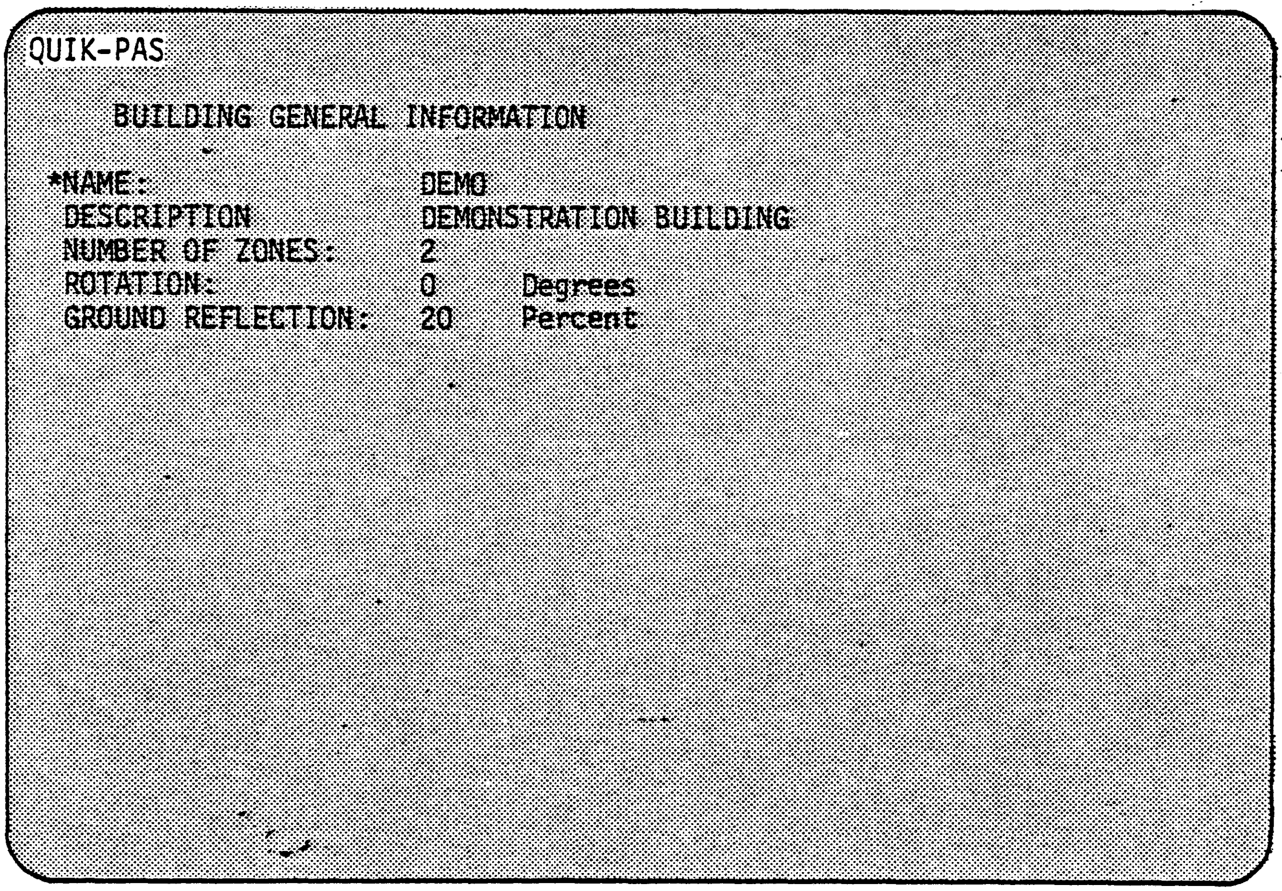


Fig. 4.4 Building General Information Description Screen

add, subtract, or change the descriptions of any of these components as desired. This can be done from the main program menu, resulting in changes to the library for all future building descriptions, or from the building description menu, resulting in changes to the library only for that specific building. The components are used to describe the various parts of the zones (e.g., a window will use a previously defined glass type, overhang, shutter, and/or sunscreen). This approach allows a designer to define a component only once and use this description throughout the building. It also allows a designer to change each part of the building individually or change all parts at once. For example, if only one window uses triple pane glass, it can be described separately, but if the same type of glass is used throughout the building, the designer can change the description of that glass component to change all of the windows at one time.

Each of the input screens utilizes a full screen editor; a user places the cursor directly into the variable fields that he or she wants to enter. Those variables which must be entered are marked with an asterisk "*" and the default values of the remaining variables are displayed. A wall description, for example, requires only three entries (name, area, and azimuth) but a designer can enter up to nineteen other variables to describe a wide variety of wall and window combinations (see fig. 4.5). Many of the default values are assigned during initialization of the program so that they can reflect state-of-the-art construction practices in one locale or the preference of a particular

```
QUIK-PAS          BUILDING: DEMO      ZONE # 1 : HOUSE

     EXTERIOR WALL AND WINDOW DESCRIPTION

 *NAME:          SOUTH
 *TOTAL AREA:    1000      Sq.Ft.
 *AZIMUTH:       0         Degrees
  TILT:          90        Degrees
  R-VALUE:       19
  WALL TYPE:     Standard
  ABSORPTANCE:   50        Percent
--------------------------------------------------------------------------
 NUMBER OF WINDOWS IN WALL: 1                  SOLAR GAIN DISTRIBUTION

 WINDOW NUMBER: 1              MASS    HEATING SEASON    COOLING SEASON
 AREA:          200      Sq.Ft.
 GLASS TYPE:    Dblpane     Zone Air       20  Percent        20  Percent
 SHUTTER:       None        Slab           50  Percent        60  Percent
 OVERHANG:      None        Wall           30  Percent        20  Percent
 SUNSCREEN:     None
```

Fig. 4.5 Wall and Window Description Screen .

designer (e.g., a designer in New England might choose a default insulation value of R-19 for a wall, whereas a designer in the southwest might prefer R-11). This feature also helps a designer to avoid obtaining misleading results from default values that are not appropriate for the region in which he or she is designing.

The description screens can be viewed almost as though they are pages in a notebook. In this sense, the menu screen is viewed as the table of contents from which all the other "pages" are accessable. Many of the screens are also accessable from related screens; for example, if the designer is looking at the "EXTERIOR WALL AND WINDOW" or "ROOF AND SKYLIGHT" screen, he or she can turn directly to the component screens of glass, overhangs, shutters, or sunscreens in order to review or change existing components or to create new ones without having to go back to the menu screen. The program keeps track of how a user accesses the various screens and always returns to the appropriate screen. The user can, however, leave the program immediately without backtracking through all of the various screens by depressing the "Escape" key.

Every item is tested <u>on entry</u> to ensure that an acceptable value has been entered. Letter type entries are tested to ensure that the entries are acceptable. Numerical entries aretested on two levels: entries that cannot be accepted by the program (e.g., a letter entry when a numerical entry is required or an entry of 120 percent when only values of 0 to 100 percent are allowed); and entries that appear to be outside of the range of reasonable values (e.g., wall insulation R-values of less than 2 or greater than 45); however, the program will accept values that are outside the "reasonable" ranges. The second level of error checking was included mainly to help prevent a designer from inadvertently entering incorrect information. The program also checks to ensure that all of the required entries have been entered correctly whenever a designer indicates that a description is complete. The completeness test occurs on three levels: on completion of each description screen; on completion of each zone; and on completion of the building. This instantaneous error checking allows a designer to correct mistakes in input immediately rather than having to wait until after the entire building description has been entered.

As mentioned above, each zone can be described with its own HVAC systems and thermostat controls. Heating and cooling systems are modeled using seasonal efficiencies or EER and ventilation systems can be modeled using fan flow rate for forced ventilation or inlet/outlet areas and stack efficiency for natural ventilation. Air-to-air heat exchangers can also be simulated. Thermostat settings are quite flexible, allowing a designer to vary heating, cooling, and ventilation setpoints and setback temperatures for each of these systems. The setback times can be set for any time of the day as can the times for return to daytime settings. The thermostat settings are entered as pairs to separate the heating season settings from the cooling season ones (see fig. 4.6).

QUICK-PAS BUILDING: DEMO ZONE # 1 : HOUSE

THERMOSTAT SETTINGS

HEATING SEASON			COOLING SEASON		
HEATING SET POINT:	68	Degrees F	HEATING SET POINT:	65	Degrees F
COOLING SET POINT:	80	Degrees F	COOLING SET POINT:	75	Degrees F
VENTING SET POINT:	75	Degrees F	VENTING SET POINT:	72	Degrees F
HEATING SETBACK:	68	Degrees F	HEATING SETBACK:	65	Degrees F
FROM:	10	P.M.	FROM:	10	P.M.
TO:	7	A.M.	TO:	7	A.M.
COOLING SETBACK:	80	Degrees F	COOLING SETBACK:	80	Degrees F
FROM:	10	P.M.	FROM:	10	P.M.
TO:	7	A.M.	TO:	7	A.M.
VENTING SETBACK:	75	Degrees F	VENTING SETBACK:	75	Degrees F
FROM:	10	P.M.	FROM:	10	P.M.
TO:	7	A.M.	TO:	7	A.M.

Fig. 4.6 Thermostat Setting Screen

Internal heat gains for each zone can be varied using one of two schemes: residential, which calls for a total daily gain and allows the designer to specify the hourly percentages of this total (fig. 4.7); or commercial, which allows the designer to specify hourly internal gains on a per square foot basis (fig. 4.8). The designer can specify Btu's or watts as units of heat in either mode.

Thermal mass can be modeled three different ways: zone heat capacity, which simulates lightweight masses such as furniture or sheetrock; isothermal masses, which simulate high conductivity masses such as water storage devices; and nodal masses, which simulate thick, low conductivity masses such as concrete walls, Trombe walls, or floor slabs.

After the designer has completed a building description he or she returns to the "SELECT PROGRAM OPTION" screen by pressing ALT-F when the "BUILDING DESCRIPTION OPTION" screen is displayed. The program will test to ensure that all necessary data has been entered and displays an appropriate error message if any is missing. If, for example, the designer had indicated that some solar gain is to be distributed into a thermal mass (see fig. 4.5), QUIKPAS will check to ensure that the mass referred to has been described and, if it has not, the program will display the error message "Thermal Mass XXXXXXXX Must Be Described." Actually, the designer would have been informed prior to this stage that a mass description was required; when he or she finished the first wall and window description that referred to the undefined mass, the program

QUIK-PAS   BUILDING: DEMO   ZONE # 1 : HOUSE

INTERNAL GAIN DESCRIPTION

*MODE: Residential   UNITS: Btus   TOTAL DAILY GAIN: 80000

SCHEDULE

HOUR	% DAILY GAIN	HOUR	% DAILY GAIN	HOUR	% DAILY GAIN
1:	4.15	9:	4.17	17:	4.17
2:	4.15	10:	4.17	18:	4.17
3:	4.15	11:	4.17	19:	4.17
4:	4.15	12:	4.17	20:	4.17
5:	4.17	13:	4.17	21:	4.17
6:	4:17	14:	4.17	22:	4.17
7:	4.17	15:	4.17	23:	4.17

Fig. 4.7 Internal Gains Screen: Residential Mode

QUIK-PAS BUILDING: DEMO ZONE # 1 : HOUSE

INTERNAL GAIN DESCRIPTION

*MODE: Commercial UNITS: Watts

SCHEDULE

HOUR	Watts/Sq.Ft.	HOUR	Warrs/Sq.Ft.	HOUR	Watts/Sq.Ft.
1:	0.5	9:	2.0	17:	2.0
2:	0.5	10:	2.0	18:	2.0
3:	0.5	11:	2.0	19:	2.0
4:	0.5	12:	2.0	20:	0.5
5:	0.5	13:	2.0	21:	0.5
6:	0.5	14:	2.0	22:	0.5
7:	0.5	15:	2.0	23:	0.5
8:	0.5	16:	2.0	24:	0.5

Fig. 4.8 Internal Gains Screen: Commercial Mode

would have displayed a warning message that the mass must be described, so it is most likely that all required data will have been entered.

The designer would probably next run the simulation program, at which time he or she will specify the climatic data that is to be used. Simulations can be performed in one of three ways: a single building description, multiple building descriptions, or parametric comparison runs. The "parametric comparison" optionallows a designer to select one variable and have the program make several simulation runs, changing that variable a specified amount for each run (e.g., change wall or roof insulation values or South glass area) and giving results that compare the various runs.

Once a simulation has been run the designer has a great deal of information available which he or she may or may not want to see presented. The output section, like the input section, is menu driven so that the designer can select only that part of the output that is of interest. By making all of the possible output available, QUIKPAS allows a designer to look at aspects of the performance of the building that he or she may decide are of importance after an initial perusal of the results.

The designer can select one of four main report categories: annual, seasonal, daily, or hourly, as well as review the building description that produced these reports (fig. 4.9). The annual report is a summary

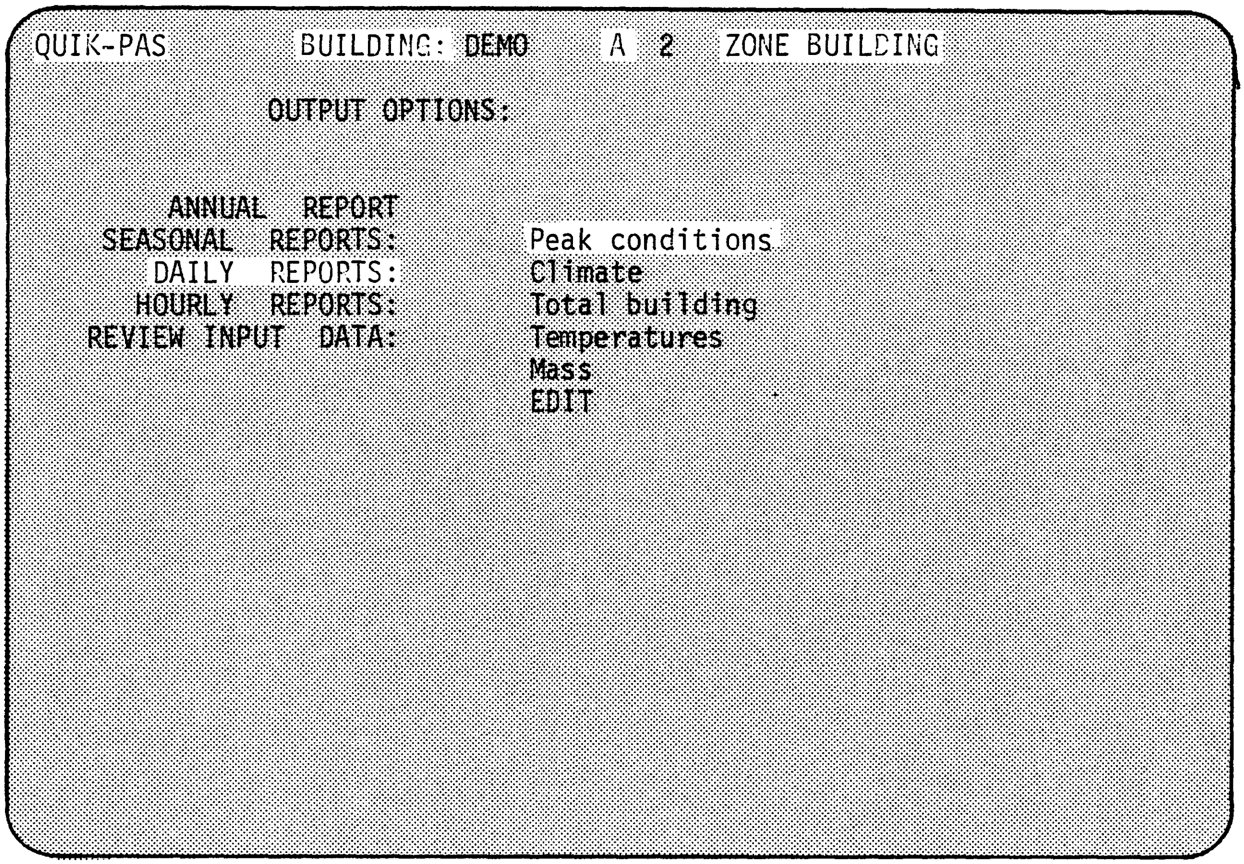


Fig. 4.9 QUIKPAS Output Options Menu

of climatic conditions, heating and cooling loads, energy consumption of the HVAC systems , and energy costs for the entire building for one year. The seasonal, daily, and hourly reports are divided into six divisions: peak conditions, total building, climate, individual zones, thermal mass, and temperature. Depending on which output report is selected, the program will request the user to specify which zone and/or season is to be displayed. In addition, by using the EDIT option, the user can specify any or all of the twenty-two reports available in any order desired (fig. 4.10). This option further enables the designer to review information in a compartmentalized fashion which helps prevent him or her from being overwhelmed by too much information being displayed at one time.

Once the selection has been made, the desired report is displayed on the screen; it consists of a title, a menu, and a table of information (fig. 4.11). Because there is too much data to be displayed at one time, the table is actually a "window" looking into a larger table. This window can be manipulated by using the cursor keys to display other parts (columns and rows) of the table. The bottom row of the table contains totals or averages (whichever is appropriate) for each column. The menu allows changing the order of the columns as well as arithmetic operations between two columns or between one column and a constant in a spreadsheet fashion. The "CALCULATE" option will create new colums which can then be labeled by the user. The "PLOT" option allows the designer to obtain a graphical view of one or more columns plotted on a vertical

```
QUIK-PAS          BUILDING:  DEMO      A   2   ZONE BUILDING

              OUTPUT OPTIONS:                        COL# COLUMN TITLE:
                                                     ------------------
                                                          VENT FLOW
         ANNUAL REPORT                                    VENTFANS ELEC. USE
     SEASONAL REPORTS:          Peak conditions           SURF. CONDUCTION
        DAILY REPORTS:          Climate                   AIR TEMP.
       HOURLY REPORTS:          Total building       (2)  HEAT SYS. FLOW
    REVIEW INPUT DATA:          Temperatures         (1)  A/C FLOW
                                Mass                      VENT FLOW
                                *NEW OPTION               INFIL FLOW
                                                          INTRNL GAIN
                                                          OPAQ. SURF. CON
                                                          GLAZ. SURF. CON
                                                          RADTN. THRU GLZ
                                                          MASS FLOW
                                                          INFIL AIR RATE
                                                          VENT AIR RATE
                                                          HEATEX AIR RATE
                                                          HEAT SYS.USE
                                                          A/C ELEC USE
                                                          HEATEX ELEC.USE
ENTER NEW MENU OPTION NAME                                FAN ELEC.USE
   OR MOVE TO OPTION AND PRESS Alt-D TO DELETE            MASS TEMPERATURES
```

Fig. 4.10 Output Options Menu Illustrating User Defined Options

QUIK-PAS BUILDING: DEMO A 2 ZONE BUILDING

DAILY REPORT OF Individual zones FOR Peak heating : Building

CHANGE COLOMN
CALCULATE
PLOT
LIST

DAY	1 1:AIR TEMP. deg. F	2 furnacel SYS.FLOW Btu	3 a/c 1 FLOW Btu	4 heatexl FLOW Btu	5 1:VENT FLOW Btu	6 1:INFIL FLOW Btu	7 1:INTRNL GAIN Btu
1	81	977	-1019	627	139	26	101
2	71	1414	-932	888	109	113	82
3	79	1819	-935	977	179	126	139
4	71	21	-1586	137	13	68	106
5	66	1459	-501	886	85	68	46
6	72	234	-1468	578	192	3	39
7	74	29	-1326	895	127	15	94
Total/Ave	73	5953	-7767	4988	844	419	607

Fig. 4.11 Typical Output Report Screen

axis versus time (by season, day, or hour, depending on the report) plotted on a horizontal axis. The "LIST" option will print the entire table (not just that part displayed by the window) to either a line printer or into a character file on the disk drive. The "list to file" option allows a report to be reproduced by a word processing program should the user desire to include the information in a seperate report. The user returns to the "OUTPUT OPTION" menu by pressing ALT-Q (Quit) or ALT-F (Finished) or can exit the program directly by using the "Escape" key.

QUIKPAS also contains a feature which is beginning to be recognized throughout the microcomputer industry as being a standard feature for any good interactive program and which is especially useful for computerized design tools (2): the ability for the user to ask for "Help" at any time during the program. Because an architect will not be constantly making energy analyses of buildings (indeed, as noted in Chapter 3, designers should eventually not have to rely on computerized design tools) it is quite likely that he or she will not become as familiar with the program as would someone who uses it on a regular basis.

QUIKPAS has two forms of help available to a user. Pressing ALT-H (Help) results in a message being displayed which explains the field that the cursor is in when the message is requested. This function would generally be used by a designer who does not understand the meaning of an input variable. For example, if the cursor was in the "ABSORPTANCE" field on the wall and window description screen (fig. 4.5), a message would be displayed giving the definition of absorptance (the percentage of heat retained by a wall from the incident solar radiation), the acceptable values (0 to 100 percent), and an explanation of the default value (50 percent is appropriate for a medium colored wall fully exposed to the sun).

Pressing ALT-L (List) will result in a display of the acceptable values for an entry. If the entry is numeric, the display will show the range of acceptable values. If the entry calls for a component selection (e.g., type of glass), the program will display the available components (e.g., Sglpane, Dblpane, Tplpane). The user can then select whichever component he or she desires, display the various components in order to review or modify them, or create a new component if none of the existing ones is appropriate.

These two functions facilitate the entry of unfamiliar information by making program documentation available on the screen so that the designer need not search through the support manual for individual input descriptions. In fact, the "List" function is necessary because the designer may very well have created a component that is not described in the support manual. Finally, if the designer forgets how to invoke these functions, he or she only needs to remember to type in "?" and the program will display a list of Alternate Key Instructions.

CONCLUSION

The microcomputer is becoming an accepted piece of equipment that will very likely be found in almost every office in the near future. Businesses have accepted it as a standard piece of office equipment, as common and almost as essential as the typewriter, because of its capacity to act as a word processor, filing system, and accounting system. The design community is becoming more and more aware of the ability of the microcomputer to aid in the design process, mainly because of the sophisticated graphics capabilities of the newer models, and the term "computer aided design" can be heard almost as often in small design firms as it can in large engineering offices.

Although still in the developmental stage, QUIKPAS is an important step in the exploration of the microcomputer as an analytical design tool. Many of the features present in QUIKPAS will certainly be found in future, more sophisticated programs. For any analytical tool to be "successful" as a design tool, it must be "useful, usable, and used" (1). QUIKPAS has the qualities needed to be all of these things. It is accurate and flexible enough to demonstrate to a designer the thermal ramifications of various design decisions (useful). The interactive full screen editor, error checking on entry, "Help" and "List" functions make the program easy to use, providing instantaneous feedback to the designer concerning design options (useable). As for being used, this is up to the individual designers who obtain the program. The author believes that, because the program is easy to learn and use, and because it provides information to the designer in terms that he or she can understand, that it will be used, hopefully in a manner that will allow the users to internalize the information provided so that they will not have to rely on the program for design purposes. This last quality is the real value of any analytical design tool.

There are certain limitations to the QUIKPAS program. For example, it can currently simulate only three thermal zones. Since many commercial buildings have five unique zones (North, South, East, West, and central core), it would be best to upgrade the program to model five zones. Commercial buildings also have more sophisticated HVAC systems than QUIKPAS can presently model; however, the recently released ASEAM program (2), a public domain program based on the ASHRAE TC 4.7 Simplified Energy Calculation Procedure has several HVAC subroutines which can be adapted for use by QUIKPAS. Future versions of the program will utilize the color graphics capabilities of the IBM PC but will be written in such a manner that a designer without these capabilities can still use the program (although it will be recommended that the designer have a color monitor because of the much greater capacity of a color screen to graphically illustrate output as opposed to the "character graphics" that a non-color monitor must use).

Some of the limitations of QUIKPAS are limitations of the machine that the program uses (i.e., speed and memory size) and the computer language (BASIC) in which it is written. The program currently takes about twenty-five minutes to simulate a one zone, one mass building, with longer run times required for more complicated building descriptions. These times should be able to be reduced to about ten minutes for the simpler building by using a "compiled" version of BASIC but BASIC is a relative slow computer language (much slower that FORTRAN, for example). Use of a parallel processor chip can also greatly increase the speed of the simulation runs. Although the BASIC language was chosen because of its universal use in the microcomputer industry, other languages that are faster than BASIC exist which would be suitable for public domain programs (most notably PASCAL or MODULA-2).

It may be misleading to use the term "microcomputer" to describe the machines of the future. The rapid improvements in the industry over the past few years are an indication of bigger (in memory) and faster computers on the horizon. In 1982, the standard microcomputer came with an 8-bit processor, 48 to 64 K bytes of RAM memory, and perhaps two floppy disk drives with 90 to 200 K bytes of storage space each. In 1983, 16-bit processors are commonplace, along with 128 to 256 K bytes of memory, floppy disks of 300 to 600 K bytes of storage, and hard "Winchester" disks with 5 to 10 Megabytes of storage are not unusual. A machine recently introduced on the market has 1 Megabyte of RAM memory (64 times as big as the machines offered a year ago) and 50 Megabyte disks are soon to be available. To understand what these numbers mean consider that CALPAS3, an annual hourly simulation program which can be run in less than five seconds, is run on a minicomputer which now has 2 Megabytes of memory.

Calculations that once took hours or required the use of expensive main-frame computers can now be accomplished on a microcomputer in minutes (the time span of a coffee break or, at worst, a lunch hour) and in the near future can be done in seconds on desk top computers. This compression of calculation time will allow analytical tools to be able to fit into the framework of the design structure (imagine getting detailed simulation reports in graphical form in a time span roughly equal to making a pencil sketch).

David Krinkel has presented a thesis that envisages an entire family of microcomputer programs which he calls TRACERY (3) that would be compatible with each other, able to make several different analyses (thermal, daylighting, acoustics, etc.) from the same data; the designer would only have to enter a building description once to make all of the analyses, thus enabling him or her to better see the trade-offs that are always inherent in design solutions. QUICKPAS would be an excellent program to fit into the TRACERY family as the thermal analysis program. With the developments certain to occur in microcomputers this type of program could soon be a reality. Such a development will greatly enhance the ability of microcomputer based analytical tools to be a viable part of the design process.

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